PATENT ABSTRACTS OF JAPAN

(11)Publication number : **06-172870**
(43)Date of publication of application : **21.06.1994**

(51)Int.CI.
C21D 9/48
C21D 8/04
C22C 38/00
C22C 38/14

(21)Application number : **04-351986**
(22)Date of filing : **09.12.1992**

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(54) PRODUCTION OF COLD ROLLED STEEL SHEET FOR EXTRA DEEP DRAWING

(57)Abstract:
PURPOSE: To easily obtain a cold rolled steel sheet for extra deep drawing, improved in Lankford value by subjecting a steel having respectively speficied contents of C, Mn, S, N, Al, Ti, etc., to hot rolling and coiling under the conditions satisfying prescribed inequalities and then performing cold rolling, annealing, etc.
CONSTITUTION: A steel which has a composition consisting of, by weight, ≤0.002°C, 0.2-1.5% Mn, ≤0.01% S, ≤0.004% N, 0.01-0.1% Al, ≤0.05% Ti, 0.001-0.02% Nb, and the balance Fe and satisfying Ti>4C+3.43N+1.5S is refined. This steel is heated up to 1100-1300°C and then rolled under the conditions satisfying inequality I [where Mn is Mn content (wt.%) in the steel, S is S content (wt.%) in the steel, and X is heating temp. (°C+273)] and also under the conditions satisfying inequality II [where Ti means (Ti content in the steel)(wt.%)-3.43μ(N content)(wt.%) and T means hot finish rolling inlet temp. (°C+273)]. Subsequently, the resulting plate is coiled at 400-750°C, pickled, cold- rolled, and annealed.

$$0.002\times(Mn - 1.72(S - 0.002)) > 10^{(-9020/X+2.929)} \quad \text{I}$$

$$Ti^{*}\times(S - 0.58(Mn - Ti^{*}\times 10^{(8620/T-5.271)})) < 2.35\times 10^{-} \quad \text{II}$$

LEGAL STATUS

[Date of request for examination]	17.09.1998
[Date of sending the examiner's decision of rejection]	19.03.2002
[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]	
[Date of final disposal for application]	
[Patent number]	
[Date of registration]	
[Number of appeal against examiner's decision of rejection]	
[Date of requesting appeal against examiner's decision of rejection]	
[Date of extinction of right]	

* NOTICES *

CLAIMS

[Claim(s)]
[Claim 1] C:0.0025% or less, Mn:0.2-1.5% which (is the same hereafter) at weight %, S:0.01% or less, N:0.004% or less, aluminum:0.01-0.1%, Less than [Ti:0.05%] and Nb:0.001-0.02% are contained. As opposed to the steel with which the relation of Ti>4C+3.43N+1.5S is filled, and the remainder consists of Fe and an unescapable impurity element Heat in the range of 1100-1300 degrees C, and this heating temperature and heat finishing rolling close side temperature satisfy the conditions of the following (1) formulas and (2) formulas. The manufacture method of the cold rolled sheet steel for super-deep drawing which rolls out on the conditions which set finishing temperature to 3 - 30 or more degree C of Ar(s), rolls round by the 400-750-degree C temperature requirement, subsequently carries out pickling, and is characterized by performing cold rolling and annealing.
[Formula 1]

$$0.002\times(Mn-1.72(S-0.002))>10^{(-9020/x+2.929)} \quad \cdots(1)$$

[Formula 2]

$$Ti^{*}\times(S-0.58(Mn-Ti^{*}\times10^{(8620/T-5.271)}))<2.25\times10^{-5} \quad \cdots(2)$$

here -- Mn: -- the amount of Mn of steel (wt%), the amount (wt%) of S of S:steel, the amount (wt%) of amount of Ti (wt%)-3.43xN of Ti*:steel, x:heating temperature (degree-C+273), and T:heat finishing rolling close side temperature (degree-C+273)
[Claim 2] The way according to claim 1 the aforementioned steel is a thing containing further B:0.0005 - 0.002%.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] Especially this invention enables the improvement of a Lankford value (r value) about the manufacture method of the cold rolled sheet steel for super-deep drawing.
[0002]
[Description of the Prior Art] In fabrication of parts, such as autoparts especially a fender, and an oil pan mechanism, deep drawability was required and the cold rolled sheet steel for super-deep drawing before and behind 2.0 has been used for the r value from the former.
[0003] Conventionally, as above cold rolled sheet steels for super-deep drawing, IF steel (Interstitial Free Steel) which added Ti or Nb required to fix C or N enough to super-low C steel is known well. However, in such IF steel, Dissolution C remained in the addition below the atomic equivalent ratio of the total amount of N, S, and C, and Ti has been said to be unable to acquire sufficient property. Furthermore, the parts with which much more advanced press-forming nature is called for are increasing in recent years with diversification of user need, or investigation of fashionability.
[0004] For this reason, it is difficult to, obtain 2.0 or more r values which can respond to the latest user need for example, although it is indicated that a good super-deep drawing steel can be manufactured to secondary elaboration-proof brittleness by fixing N by Ti by compound addition of Ti and Nb, and fixing C by Nb in JP,61-32375,B.
[0005] Moreover, recently, it is towards reduction of C, N, and S for the purpose of the improvement in an r value, and the cost rise of steel-manufacture refinement is becoming indispensable.
[0006] As mentioned above, at the conventional cold rolled sheet steel for super-deep drawing, although advance of a certain grade was obtained with Ti addition IF steel and Ti-Nb compound addition IF steel, relief of the operating condition accompanying much more improvement in the various weighted solidity which makes an r value representation, and it, improvement in the yield, etc. also have many left-behind technical problems.
[0007] this invention aims at offering the manufacture method of the cold rolled sheet

steel for super-deep drawing aiming at the improvement of much more r value in view of a ****** situation.

[0008]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, as a result of inquiring wholeheartedly, this invention persons can improve an r value further, and manufacture conditions find out the manufacture method of the comparatively easy cold rolled sheet steel for super-deep drawing, and they complete this invention here.

[0009] this invention Namely, C:0.0025% or less, Mn:0.2-1.5%, S:0.01% or less, N:0.004% or less, aluminum:0.01-0.1%, Less than [Ti:0.05%] and Nb:0.001-0.02% are contained. Fill the relation of Ti>4C+3.43N+1.5S and the need is accepted. As opposed to the steel with which further B:0.0005 - 0.002% is contained, and the remainder consists of Fe and an unescapable impurity element Heat in the range of 1100-1300 degrees C, and this heating temperature and heat finishing rolling close side temperature satisfy the conditions of the following (1) formulas and (2) formulas. The manufacture method of the cold rolled sheet steel for super-deep drawing which rolls out on the conditions which set finishing temperature to 3 - 30 or more degree C of Ar(s), rolls round by the 400-750-degree C temperature requirement, subsequently carries out pickling, and is characterized by performing cold rolling and annealing is made into the summary.

[Formula 3]

$$0.002\times(Mn-1.72(S-0.002))>10^{(-9020/x+2.929)} \quad \cdots(1)$$

[Formula 4]

$$Ti^{*}\times(S-0.58(Mn-Ti^{*}\times10^{(8620/T-5.271)}))<2.25\times10^{-5} \quad \cdots(2)$$

here -- Mn: -- the amount of Mn of steel (wt%), the amount (wt%) of S of S:steel, the amount (wt%) of amount of Ti (wt%)-3.43xN of Ti*:steel, x:heating temperature (degree-C+273), and T:heat finishing rolling close side temperature (degree-C+273)

[0010] this invention is explained still in detail below.

[0011]

[Function]

[0012] First, the knowledge which came to make this invention is as follows.

[0013] That is, in super-low C-IF steel, the detailed sludge which deposits by the rolling cooling process can be decreased by making it deposit as MnS, without making S dissolve as much as possible, by the time it rolls out by finishing from the time of HDR or slab reheating by carrying out optimum dose addition of the amount of Mn and the amount of Ti according to heating temperature. Consequently, the grain growth possibility at the time of recrystallization annealing after cold-rolling could be raised, and it found out that a high r value was obtained.

[0014] Moreover, although it was so good that there were little Dissolution S and N and Dissolution C at the time of annealing heating in order to have raised grain growth possibility, the knowledge of grain growth possibility required if Ti addition is above (1.5S+3.43N+4C), and the dissolution S at the time of heating is 20 ppm or less when the amount of C is 30 ppm or less, in order to reduce a detailed sludge and to obtain a high r

value being securable was carried out (drawing 1).
[0015] On the other hand, the knowledge of the ability to also carry out [detailed]-izing of the hot-rolling board particle size was carried out, without spoiling grain growth possibility comparatively by adding Nb of optimum dose, or B, although eye a good hatchet and hot-rolling board particle size had grain growth possibility disadvantageous to be easy to become big and rough and to obtain a high r value in ****. Moreover, in ****, since MnS deposited from an elevated temperature comparatively, the knowledge also of being also suitable for heat slab direct delivery rolling (HDR) was carried out. By these, there is no unreasonableness in steel-manufacture refinement comparatively, and a super-deep drawability cold rolled sheet steel can be obtained.
[0016] Although this invention adds a still more detailed examination and is completed based on the above knowledge, the reason for limitation of the chemical composition of the steel in this invention is explained first.
[0017] C: The high r value was obtained only after adding Ti with the conventional sufficient IF steel to fix it including about 0.0030% of C. As for this, Dissolution C affects movement of transposition in cold-rolling or recovery recrystallization process, and suppressing development of a texture (111) is known with the cause. However, since the amount of C has [raising grain growth possibility] the fewer possible good one, in this invention, the amount of C is made 0.0025% or less. Absolute magnitude of the carbide formation element added for the deposit and fixation can be lessened by this, and the amount of a sludge can also be reduced.
[0018] Mn:Mn forms a sulfide from an elevated temperature, and reduces the amount of dissolution S, and is an element important for reducing a detailed sludge. It is necessary to add at least 0.2% or more to demonstrate this effect. However, since an r value will deteriorate if it adds so much, the upper limit is made into 1.5%.
[0019] It is necessary to add Ti:Ti more than the atomic equivalent ratio of S, N, and C at least to be an element required to fix N and C, and fix these. That is, it adds so that the relation of Ti>4C+3.43N+1.5S may be filled. However, since ductility not only falls, but it will become a cost rise if it exceeds 0.05%, let 0.05% be an upper limit.
[0020] S: The absolute magnitude of the sulfide which deposits if the amount of S is increased also increases, and in order to degrade the local ductility represented by elongation flange nature, you have to suppress the amount of S to 0.01% or less.
[0021] aluminum:aluminum needs at least 0.01% of aluminum to be an element required for deoxidation and fully perform deoxidation. However, since the deoxidation effect not only reaches saturation, but aluminum system inclusion will be generated and a moldability will be degraded if it exceeds 0.1%, let 0.1% be an upper limit.
[0022] N: Since the addition of Ti required to fix this with the increase in N increases, and cause a cost rise, and also the amount of sludges increases, grain growth possibility deteriorates and it is hard coming to obtain the improvement in an r value, make the amount of N a low and since [although it is preferably / 0.002% or less of / desirable,] a minimum value required to acquire the desired quality of the material is 0.004% into 0.004% or less as much as possible.
[0023] Nb:Nb suppresses the recrystallization of an austenite and is effective in raising an r value by carrying out grain refining of the hot-rolling board particle size. For that

purpose, at least 0.001% or more is required. On the other hand, although it is used in IF steel in order to fix C generally, NbC is detailed and has the operation which suppresses grain growth possibility. Therefore, although the proper addition of Nb changes with Ti additions, if it is made 0.02% or less, since grain growth possibility is comparatively good, let this be an upper limit.

[0024] B: Since B suppresses an austenite-ferrite transformation and has the effect of the formation of hot-rolling board detailed, it can add if needed. the effect is acquired when adding -- being alike -- since ductility will be reduced if it adds so much 0.0005% or more, although it is the need, the range is made into 0.0005% or more and 0.002% or less

[0025] Next, the manufacture conditions of this invention are explained.

[0026] What is necessary is just to ingot this invention steel with the converter usually performed. Although the ingoted molten steel is made into a slab, as the method, an ingot making method or a continuous casting process is sufficient. Although a slab is inserted in a hot-rolling heating furnace after being cooled to a room temperature, the HDR method which does not cool to an end room temperature but is directly rolled out in that case, or the HCR method inserted in a heating furnace may be used. About the heating temperature of a slab, although usual 1100-1300 degrees C are sufficient, if finishing temperature can secure three-Ar -30 degrees C or more, the low way is desirable as much as possible.

[0027] However, heating temperature must fill the following formula (1).

[Formula 5]

$$0.002\times(Mn-1.72(S-0.002))>10^{(-9020/x+2.929)} \quad \cdots(1)$$

Here, they are the amount of Mn of Mn:steel (wt%), the amount (wt%) of S of S:steel, and x:heating temperature (degree-C+273).

[0028] It means depositing most and setting the amount of dissolution S to 20 ppm or less by setting to MnS dissolution S included in steel filling this relational expression (1), at i.e., the time of heating temperature.

[0029] Hot-rolling conditions are not restricted especially other than finishing rolling close side temperature and finishing temperature. With heating temperature, management of finishing rolling close side temperature needs to be important, and needs to fill the following formula (2).

[Formula 6]

$$Ti^{*}\times(S-0.58(Mn-Ti^{*}\times10^{(8620/T-5.271)}))<2.25\times10^{-5} \quad \cdots(2)$$

Here, they are the amount of Mn of Mn:steel (wt%), the amount (wt%) of amount of Ti (wt%)-3.43xN of Ti*:steel, and T:heat finishing rolling close side temperature (degree-C+273).

[0030] Just before finishing rolling, most S deposits as MnS and filling this relational expression (2) means that TiS does not exist.

[0031] Moreover, a rolling end in an austenite region is comparatively desirable. Finishing temperature is A3 point. - If it becomes less than 30 degrees C, since cold-rolling and the texture which injures the property after annealing will be formed, finishing temperature is A3 point. - You may be 30 degrees C or more. In addition, although cooling from a rolling

end to winding is so desirable that it is quick, it does not limit.
[0032] Although winding temperature needs to regulate for fixation of Dissolution C, in low steel, low winding also has very few amounts of residual dissolution C, and since the amount of C does not almost have the fall of an r value, it makes the minimum 400 degrees C. However, since problems, such as many problems in elevated-temperature winding temperature, for example, a scale, and surface discontinuity, will occur if winding temperature exceeds 750 degrees C, let 750 degrees C be an upper limit.
[0033] Next, pickling of this is carried out and cold rolling and annealing are performed. although especially cold-rolled conditions are not limited, so that the rate of cold-rolling is 65 - 90% -- an r value -- since improvement is obtained, it is desirable If 65% of cold-rolling is added at worst, a desired property will be acquired, and on the other hand, it is impossible to complete 90% or more of cold-rolling with one rolling by the usual tandem mill. Soaking temperature does not need to regulate heating and especially cooling conditions, if annealing conditions are the ranges of less than three Ar(s) more than a recrystallizing temperature. Since a random nucleation will be brought about at the time of an gamma->alpha transformation and a gamma value will deteriorate extremely if it heats to an austenite region exceeding less than three Ar(s), it minds.
[0034] Since C and N are almost fixed by Ti before cold-rolling and the cold rolled sheet steel for super-deep drawing by this invention hardly decomposes after cold-rolling and annealing, although especially overaging processing is not required, plate leaping of the overaging band currently installed in the present continuous-annealing line is carried out, and even if it adds overaging processing which is adopted as usual aluminum killed steel, the quality of the material is not degraded at all.
[0035] Next, the example of this invention is shown.
[0036]
[Example]
[0037] After hot-rolling the sample offering steel of a chemical composition shown in Table 1 on condition that Table 2 and 3, it cold-rolled by 80% of rolling reduction after winding and pickling, and the cold-rolled board of 0.8mm of board thickness was obtained. The tension test was performed, after giving annealing for 850 degree-Cx 1 minute to this cold-rolled board and performing temper rolling 1%. A test result is shown in Table 2 and 3 with an r value.
[0038] In Table 2, each of examination No.1, No.2, No.4, and No.6 is this invention material, and it turns out that it has the outstanding deep drawability. these -- receiving -- comparison material -- No.3 have low rolling temperature, and since the disadvantageous rolling texture for deep drawability was formed, high deep drawability is not obtained comparison material -- No.5 have low winding temperature, and since Dissolution C exists, high deep drawability is not obtained Moreover, each other comparison material has many amounts of a detailed sludge, and cannot obtain the deep drawability which was excellent since grain growth possibility was bad.
[0039] Table 3 is an example about B addition steel. Each of No.10, No.11, No.13, and No.15 is this invention material, and has the outstanding deep drawability. Since No.12 of comparison material and No.14 had low rolling temperature and the disadvantageous rolling texture for deep drawability was formed to these, high deep drawability cannot be

obtained. comparison material -- No.16 have low winding temperature, and since Dissolution C exists, high deep drawability is not obtained comparison material -- No.17 have many B additions and cannot obtain the deep drawability grain growth possibility excelled [deep drawability] in the low sake

[0040]

[Table 1]

鋼記号	供試鋼の化学成分 (wt%)										備考
	C	Si	Mn	P	S	Ti	Nb	B	Al	N	
A	0.0006	0.005	0.35	0.005	0.0030	0.020	0.005	—	0.025	0.0020	本発明材
B	0.0012	0.006	0.60	0.005	0.0058	0.034	0.012	—	0.022	0.0028	〃
C	0.0024	0.011	0.60	0.006	0.0054	0.035	0.010	—	0.025	0.0015	〃
D	0.0020	0.010	0.12	0.011	0.0066	0.052	—	—	0.030	0.0026	比較材
E	0.0007	0.010	1.80	0.011	0.0060	0.023	0.011	—	0.031	0.0025	〃
F	0.0019	0.019	0.60	0.010	0.0060	0.045	0.045	—	0.025	0.0022	〃
G	0.0009	0.010	0.35	0.009	0.0050	0.028	0.010	0.0010	0.023	0.0025	本発明材
H	0.0020	0.011	0.60	0.010	0.0048	0.040	0.010	0.0010	0.025	0.0020	〃
I	0.0022	0.010	0.99	0.010	0.0050	0.042	0.011	0.0009	0.024	0.0022	〃
J	0.0018	0.010	0.35	0.010	0.0060	0.045	0.010	0.0051	0.030	0.0020	比較材

[0041]

[Table 2]

[0042]
[Table 3]

試験No.	鋼記号	加熱温度(℃)	仕上圧延入側温度(℃)	巻取温度(℃)	YP(N/mm²)	TS(N/mm²)	El(%)	r値	式(1)	式(2)
1*	A	1200	1050	650	148	285	55	2.45	○	○
2*	A	1120	1050	650	150	287	55	2.55	○	○
3	A	1080	950	600	157	290	54	1.95	○	×
4*	B	1150	1050	650	160	300	53	2.45	○	○
5	B	1150	1050	300	168	305	52	1.90	○	○
6*	C	1150	1050	650	170	310	51	2.40	○	○
7	D	1200	1050	650	150	290	54	1.95	×	×
8	E	1200	1050	650	195	366	45	1.70	○	○
9	F	1200	1050	650	177	311	48	1.90	○	×

(注1) *は本発明材を示す。

(注2) r値は圧延方向に平行(r_L)、直角(r_C)、及び45°(r_N)方向の値を次式で平均したものである。

$$r = (r_L + r_C + 2r_N)/4$$

(注3) 式(1)及び(2)の欄は本発明におけるそれぞれの式を満たしている場合を○、満たしていない場合を×にて表示した。

試験 No.	鋼記号	加熱温度 (℃)	仕上圧延入側温度(℃)	巻取温度 (℃)	YP (N/mm²)	TS (N/mm²)	El (%)	r値	式(1)	式(2)
10*	G	1200	1050	650	165	305	52	2.40	○	○
11*	G	1120	1050	650	168	306	52	2.50	○	○
12	G	1200	950	300	173	307	51	1.85	○	×
13*	H	1200	1050	650	175	318	50	2.35	○	○
14	H	1200	950	650	179	319	49	1.95	○	×
15*	I	1120	1050	650	185	345	46	2.35	○	○
16	I	1200	1050	300	186	345	46	1.90	○	○
17	J	1200	1050	650	210	385	43	1.70	○	×

（注1）＊は本発明材を示す。

（注2）r値は圧延方向に平行(r_L)、直角(r_C)、及び45°(r_N)方向の値を次式で平均したものである。

$$r = (r_L + r_C + 2r_N)/4$$

（注3）式(1)及び(2)の欄は本発明におけるそれぞれの式を満たしている場合を○、満たしていない場合を×にて表示した。

[0043]
[Effect of the Invention] Since the cold rolled sheet steel for super-deep drawing which has improved the r value further can be manufactured on comparatively easy manufacture conditions according to this invention as explained in full detail above, the effect which contributes to the press-working-of-sheet-metal nature improvement of the steel plate for press working of sheet metal used for the automobile body, an oil pan mechanism, etc. is large.

[Translation done.]